PFRP Pelagic Fisheries Research Program

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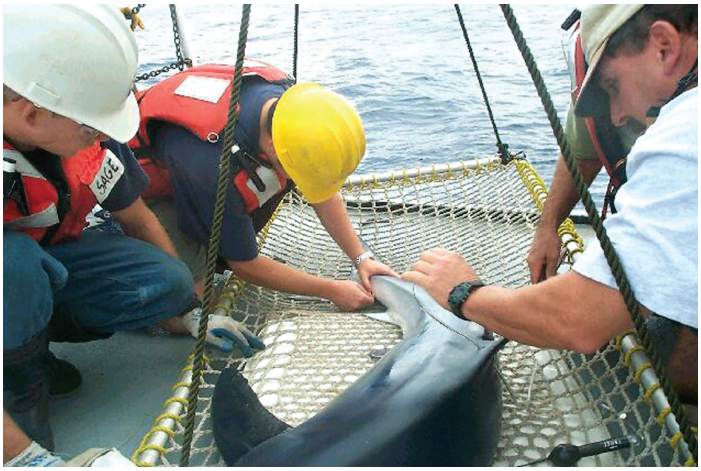
Predicting Post-Release Survival in Pelagics

Nuno Fragoso and Chris Moyes

Catch-and-release sports fishing and non-retention of commercially caught fish are justifiable management options only if there is a reasonable likelihood that released fish will survive the trauma of catch-and-release. Because of this, successful management strategies in sports fisheries and commercial fisheries require information about the prospects for survival of released fish. All recreational anglers and commercial fisherman who practice catch-and-release fishing hope that the released fish will survive. But while it is safe to say that 100% of retained fish will die, it is not known what proportion of released fish will survive. Tag-and-release studies, which have been used broadly within fisheries management, frequently find significant post-release mortality, often days or weeks after release. These studies are vital to assessing post-release survival, but they can be difficult and expensive to implement. In addition, conclusions from tag-and-release studies are often difficult to extrapolate to other species; factors such as fish size, water temperature, fight time and fishing gear can influence survival.

Using funds provided by the Pelagic Fisheries Research Program (PFRP), we have been working closely with personnel from the National Marine Fisheries Service (NMFS) to develop tools that we hope will reduce the need for tagging studies. Whereas tagging studies assess how many fish survive, we are trying to understand why fish die. We are developing a set of diagnostic tools to assess the biochemical and physiological condition of fish captured on various gear. Our application of these tools is closely coordinated with tagging studies by Rich Brill (NMFS, Kewalo Research Facility) and Mike Musyl (PFRP and Joint Institute for Marine and Atmospheric Research).

We focused first on the post-release survival of blue sharks, which are frequent by-catch of Pacific longliners. Using the NMFS vessel *Townsend Cromwell*, we captured blue sharks on scientific longline gear. Blood samples were collected from approximately 20 sharks that were fitted with pop-off satellite archival tags (PSATs). Analysis of the blood samples allowed us to evaluate the physiological condition of the sharks when they were released, and the information from the PSATs establishes how long the sharks survived. Our goal is to develop predictors of survival based upon analysis of a single blood sample taken just prior to release. Although we focused first on blue sharks, we are anxious to apply this approach broadly to other commercial and recreational fisheries.



Queen's University researcher Nuno Fragoso (center) collects blood from a blue shark while NMFS scientist Richard Brill (right) attaches a PSAT to the dorsal fin.

Analysis of Blood Samples

When a fish is caught, it experiences many different physiological challenges that can affect its long-term survival. Our analysis is similar to that used by doctors examining a patient in an emergency room. Every few seconds each red blood cell passes through the heart, travels along blood vessels that permeate the tissues, and returns to the heart. When blood passes through the body, it is changed in many ways that are illustrative of the state of the tissues—and a great deal of information about an animal's health can be obtained from a blood sample.

Hooked fish may lose significant amounts of blood. If too much blood is lost, a fish may no longer be able to provide sufficient oxygen to its tissues. Blood loss is assessed by measuring

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hematocrit, which reflects the level of blood cells in circulation. When fish are captured on fishing gear, the vigorous swimming activity can deplete energy stores. When any animal undergoes extreme exercise, muscles produce high levels of lactic acid, which is released into the circulatory system; blood lactic-acid levels therefore reflect the amount of exercise an animal has experienced. Maintaining an ability to swim after exhaustive exercise is important to evade predators, and critical for large pelagic species that must continue swimming to breathe. If fish have used too much metabolic fuel deposits, they may be unable to recover from an exercise bout (Moyes and West, 1995).

Strenuous exercise also results in muscle damage. Other forms of tissue damage could conceivably arise as a result of capture; these include heart attacks, kidney failure, liver damage and brain damage. Damaged tissues release their intracellular contents into the circulatory system, and because many cells possess unique cellular markers, the presence of these molecules in the blood can be used as an index of tissue damage. By characterizing the profile of blood proteins, we are able to assess the degree of tissue damage. For example, when humans suffer heart attacks, their heart cells release the proteins creatine kinase and troponin I into the plasma. On the other hand, acute liver cell damage results in the release of the proteins alanine aminotransferase and aspartate aminotransferase. For this reason, comprehensive analysis of plasma constituents can provide many insights into animal health.

We are also using the properties of blood cells themselves to assess the extent of tissue damage. When fish blood experiences hazardous conditions such as high temperature or oxidative stress, it can activate a line of defense that minimizes the damage to the blood cell. This "stress response" is recognized by stimulation of genes that lead to production of a suite of protective proteins called heat shock proteins, or hsp. Our analysis of hsp synthesis can be used to categorize the extent of the stress experienced by the blood cells (Currie, Tufts and Moyes, 1999).

As of May 2002, we have completed analysis of the first year of our study. A second set of sharks was sampled and tagged in April.

Outcome of Tagging Studies

In recent years, sharks have comprised about 45% of the catch on longline research cruises aboard the *Townsend Cromwell*. The dominant shark species caught has been blue sharks, and in the past 2 years we have collected blood samples from 46 blues, 31 of which were fitted with PSATs by Brill and Musyl. These tags will provide environmental and behavioral details about these animals (PFRP Newsletter Volume 6, #3). They will also provide a record of survival upon release. Blood samples also were collected from 4 blue sharks that were morbid upon capture or released without tags.

The PSAT data from the blue sharks tagged in 2001 has shown that the sharks are remarkably resilient. Although none of the 16 sharks we sampled died within a week of release, many displayed clear signs of stress:

- six had elevated creatine kinase levels and lactate dehydrogenase levels, which are indicative of muscle damage;
- five had very high levels of lactic acid, which is indicative of exhaustive exercise;
- one shark that was dead when captured showed signs of a fatal heart attack, its blood laced with high levels of the heart protein troponin I; and,
- all of the sharks showed some signs of oxidative stress as demonstrated by heat shock protein mRNA blotting.

Following analysis of the blood samples collected in April from 24 blue sharks, we will expand our analysis of stress indicators to help understand the factors that cause delayed mortality of sharks and other large pelagics upon release. We believe these studies can be a valuable tool for fisheries managers, and are anxious to apply the technology to other fisheries.

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Chris Moyes is an Associate Professor at Queen's University in Kingston, Canada. A comparative physiologist, he studies the ways in which cells respond to stressful conditions, focusing on the role of energy metabolism. For more information on his research, visit http://biology.queensu.ca/~moyesc/.

Recreational Meta-Data: Using Tournament Data to Describe a Poorly Documented Pelagic Fishery

Daniel S. Curran, Paul Dalzell and Joseph O'Malley

The Recreational Meta-Data Project was initiated to identify and compile into databases the diverse sources of information on Hawai'i's pelagic recreational and sports fishing over the past 50 years. No comprehensive, official record of Hawai'i's recreational fishery exists, but there are many sources of information in the form of surveys, previous studies, club records, newspaper articles, and fishermen's logbooks. Some fisheries researchers have found such irregular data sources to be valuable when examined in aggregate or over a long period of time. Our project is amassing a database that attests to the large scope of Hawai'i's poorly documented pelagic recreational fishery.

Background

Hawai'i's recreational anglers have always enjoyed the freedom to fish without the burden of licensing and data collection from government agencies. Efforts to license recreational anglers did occur after the legislature repealed a defunct salt-water licensing program in 1949 (Ball, 1975), but the efforts failed due to strong public sentiment against having to pay even a nominal fee for access to ocean resources that traditionally have been free to all. This has resulted in a lack of historical documentation about the number of anglers and their catch, which has made it difficult for agencies to consider recreational fishing concerns when making policy decisions about allocation of marine resources.

Recreational fishing does play a significant role in the lives and economics of Hawai'i's populace. A survey in 1996 estimated that 260,005 anglers spent more than $130 million in direct expenditures to participate in recreational fishing in Hawai'i (Maharaj and Carpenter, 1996). Periodically, other surveys have documented the importance of pelagic recreational fishing in Hawai'i, but there exists no continuous, comprehensive record of recreational fishing, and most surveys point out the need for such a record (Hamilton, 1998; Kahiapo and Smith, 1994). Our project is an effort to provide enough historical documentation to enable examination of recreational data over a span of several years, thus ensuring that recreational concerns are addressed in future management decisions.

Research Methods

First, we scanned all the reports and previous surveys we could obtain, converted them into electronic files, and inputted accompanying tables into spreadsheets. Next, we began contacting different anglers, fishing clubs, and tournament directors throughout Hawai'i, and were pleased with the positive response. To date, we have received information on 27 different tournaments from 6 different clubs, and we expect to receive information on about 6 more tournaments. We have annual information covering more than 20 years of catch and effort, and some tournaments are well documented.

Once obtained, tournament information is copied and returned to the provider along with a spreadsheet and summary charts. Information in the form of "radio call-in logs" or official weigh-in slips is then keypunched into our database for analysis. When a boat hooks and lands a fish during a tournament, it is required to radio in an official report of the place, species and estimated weight of the catch. This running log, coupled with an official tournament weigh-in slip completed at the end of the fishing day, is then integrated into our database.

Results and Discussion

Tournament information has been the largest source of data collected, providing valuable insights into the nature and scope of Hawai'i's pelagic recreational fishery. Unfortunately, there is no standard methodology for reporting tournament catches, so the information we received varies from tournament to tournament.

Information on effort, catch and tournament totals illustrates the unique nature of tournament reporting habits (Figure 3). Most tournaments do not differentiate between bigeye tuna (*Thunnus obesus*) and yellowfin tuna (*T. albacares*); these species are listed simply as "ahi." Reports listing marlin can also refer to one or more of several *Istiophoridae* species, while skipjack tuna (*Katsuwonus pelamis*) is only recorded for some of the tournaments. Despite these vagaries of species identification, tournament records do provide insight into hook-up rates, catch composition, and average catch weight (Figure 1).

Data from a single tournament plotted across a time series are useful in determining cyclical peaks in catch abundance of different species (Figure 2). Catching a thousand-pound marlin is the goal of tournament participants, but the catch of mahimahi (*Coryphaena hippurus*) and ahi dominates the numerical catch totals. Although catch per unit effort (CPUE) indices do show cyclical trends in catch abundance within a single tournament and species group, CPUE trends that were compared across tournaments for a single species group do not appear to be correlated (Figure 3).

Originally, we thought we would be able to construct weight-frequency charts from the radio logs in order to discern trends in size-at-catch within the tournament fishery. Unfortunately, the practice of rounding estimated weights compounded by the lack of accurate species identification has so muddied the picture that weight-frequency charts probably will not provide much information to fisheries researchers (Figure 4).

Data from all tournaments combined show that participants rely heavily on fish aggregation devices (FADs) placed by the State of Hawai'i. Off the leeward coast of O'ahu, more than 86% of the

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Recreational Meta-Data (continued from page 3)

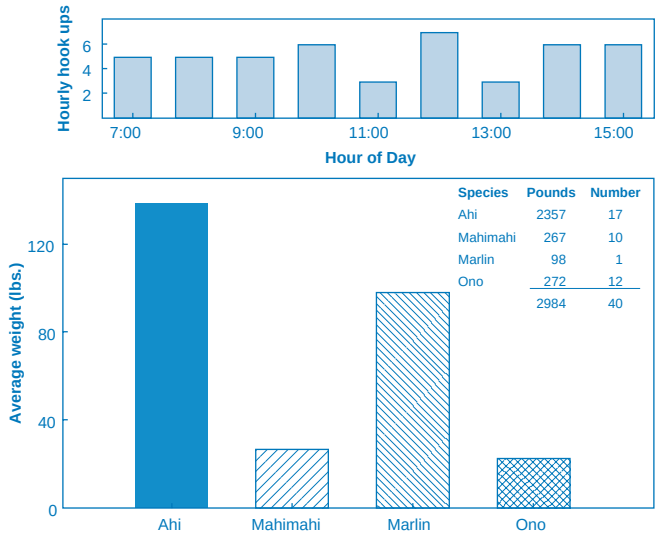

Figure 1. Summary results from a 28-boat tournament held in July 2000 on Kaua'i, showing total catch and average weight in pounds for each species group (Ahi= *Thunnus obesus* and *T. albacares*, Mahimahi= *Coryphaena hippurus*, Marlin= *Istiophoridae*, Ono= *Acanthocybium solandri*).

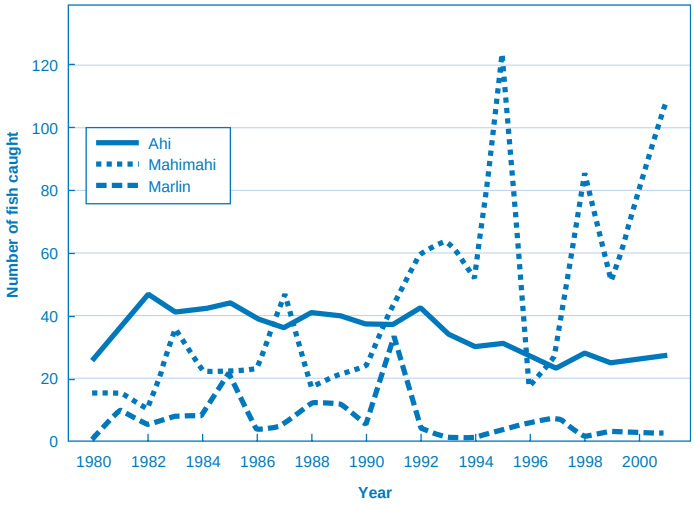

Figure 2. Annual tournament held off of leeward coast of O'ahu 1980–2001 showing numerical predominance of ahi (*Thunnus obesus* and *T. albacares*) and mahimahi (*Coryphaena hippurus*) over marlins (*Istiophoridae*) in tournament catch.

catch from all tournaments comes from the five geographic locations that contain FADs. Similarly, catch plots from tournaments off the island of Hawai'i show that almost all of the catch for these tournaments comes from areas that contain FADs (Figure 5).

Conclusion

Developing a clear understanding of the scope and nature of Hawai'i's pelagic recreational fishery is vital to efforts to draw an

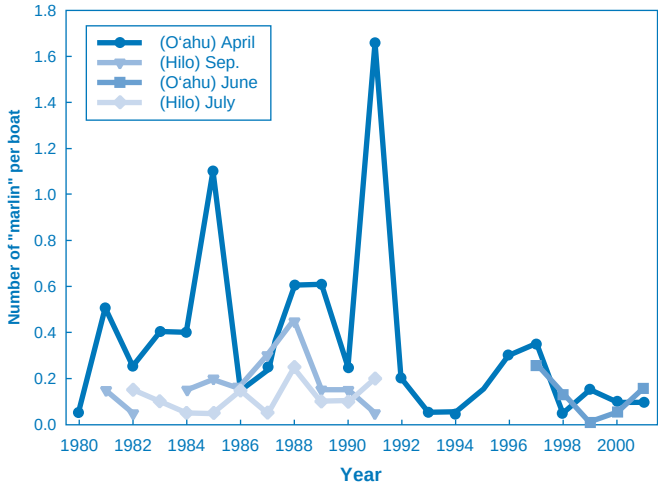

Figure 3. Catch per unit effort indices as number of marlin (*Istiophoridae*) per boat per day from 4 tournaments held off of the islands of O'ahu and Hawai'i.

accurate picture of this poorly documented fishery. This project has filled many gaps in our knowledge while illustrating the need to continue collecting information from poorly documented recreational activities. Without such an effort, it will be difficult for recreational interests to be reasonably considered when agencies weigh management issues. We feel that the information gathered so far by this project can serve as a springboard to facilitate continued data collection at fishing tournaments in Hawai'i.

Acknowledgments

We would like to thank Kanoe Renaud and all club members who willingly provided tournament information, and the following clubs in particular: Hawai'i Yacht Club, Waikiki Yacht Club, Port Allen Fishing Club, Westside Boat Club, Hilo Trollers, Wai'anae Boat Fishing Club, and the Hawai'i International Billfish Association.

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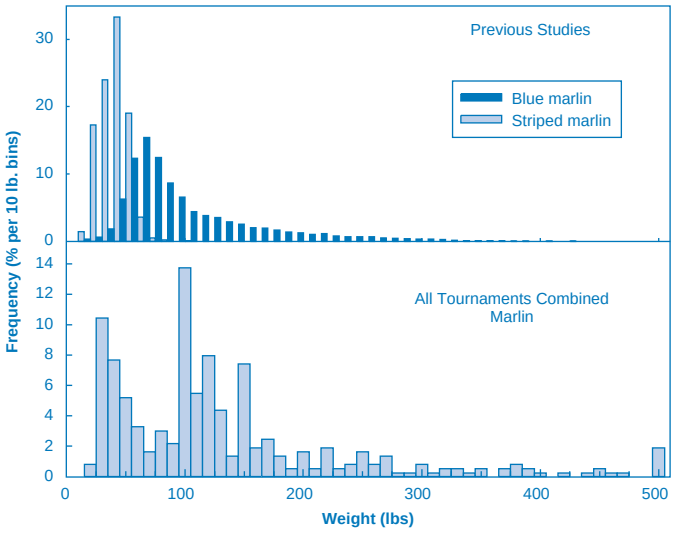

Figure 4. Size class frequencies for marlin catch from previous data on blue marlin (*Makaira mazara*) and striped marlin (*Tetrapturus audax*) in the Central Pacific, compared with size class frequencies from 27 Hawai'i tournaments from 1959–2001.

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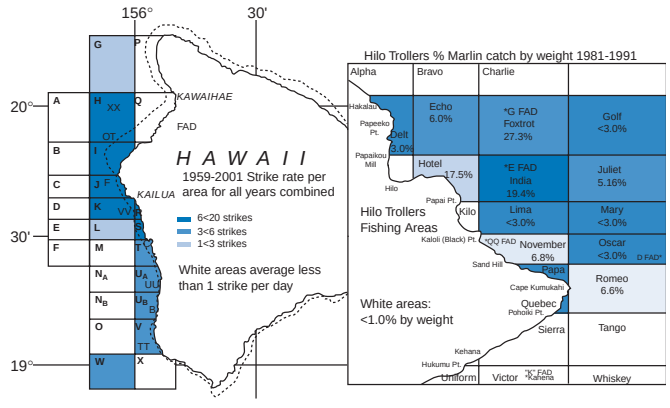

Figure 5. Tournament catch locations from the island of Hawai'i illustrating the importance of the location of FADs, and the predominance of catch coming from areas that contain FADs.

Upcoming Events

The Fifteenth Meeting of the Standing Committee on Tuna and Billfish (SCTB)

The Fifteenth Meeting of the SCTB will be held in the Hawai'i Convention Center in Honolulu July 22–27, 2002. It is expected to attract special attention because the nascent Western and Central Pacific Fisheries Commission (of the MHLC) will be indirectly seeking SCTB advice on the status of major tuna stocks in the region. Further details and a provisional agenda for SCTB 15 can be found on the PFRP website (http://imina.soest.hawaii.edu/PFRP/).

Meeting of the Scientific Coordinating Group

In addition, representatives at the MHLC Prep Con 2, held late in February in Papua New Guinea, agreed to establish a Scientific Coordinating Group (SCG) to receive information on the status of skipjack, yellowfin, bigeye and southern albacore tuna, and provide interim management advice to the Prep Con. The first meeting of the SCG will follow SCTB15 on July 29–31 at the East-West Center in Honolulu. Visit the PFRP web site for more information.

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